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Solid Waste and Emergency Response (5102G)
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A Citizen's Guide to Soil Vapor Extraction

and Air Sparging

Technology Innovation Office
Technology Fact Sheet

What is soil vapor extraction?

Soil vapor extraction, known as SVE, is the most frequently selected innovative treatment at Superfund sites. It is a relatively simple process that physically separates contaminants from soil. As the name suggests, SVE *extracts* contaminants from the *soil* in *vapor* form. Therefore, SVE systems are designed to remove contaminants that have a tendency to *volatilize* or evaporate easily. SVE removes *volatile* organic compounds (VOCs) and some *semi-volatile* organic compounds (SVOCs) from soil beneath the ground surface in the unsaturated zone—that part of the subsurface located above the water table. By applying a vacuum through a system of underground wells, contaminants are pulled to the surface as vapor or gas. Often, in addition to vacuum extraction wells, air *injection* wells are installed to increase the air flow and improve the removal rate of the contaminant. An added benefit of introducing air into the soil is that it can stimulate *bioremediation* of some contaminants.

SVE is sometimes called in situ volatilization, enhanced volatilization, in situ soil venting, forced soil venting, in situ air stripping, or soil vacuum extraction.

What is air sparging?

Used alone, soil vapor extraction cannot remove contaminants in the *saturated* zone of the subsurface, the water-soaked soil that lies below the water table. At sites where contamination is in the saturated zone, a process called air sparging may be used along with the SVE system. Air sparging means pumping air into the saturated zone to help flush (bubble) the contaminants up into the unsaturated zone where the SVE extraction wells can remove them (Figure 1).

For air sparging to be successful, the soil in the saturated zone must be loose enough to allow the injected air to readily escape up into the unsaturated zone. Air sparging, therefore, will work fastest at sites with coarse-grained soil, like sand and gravel.

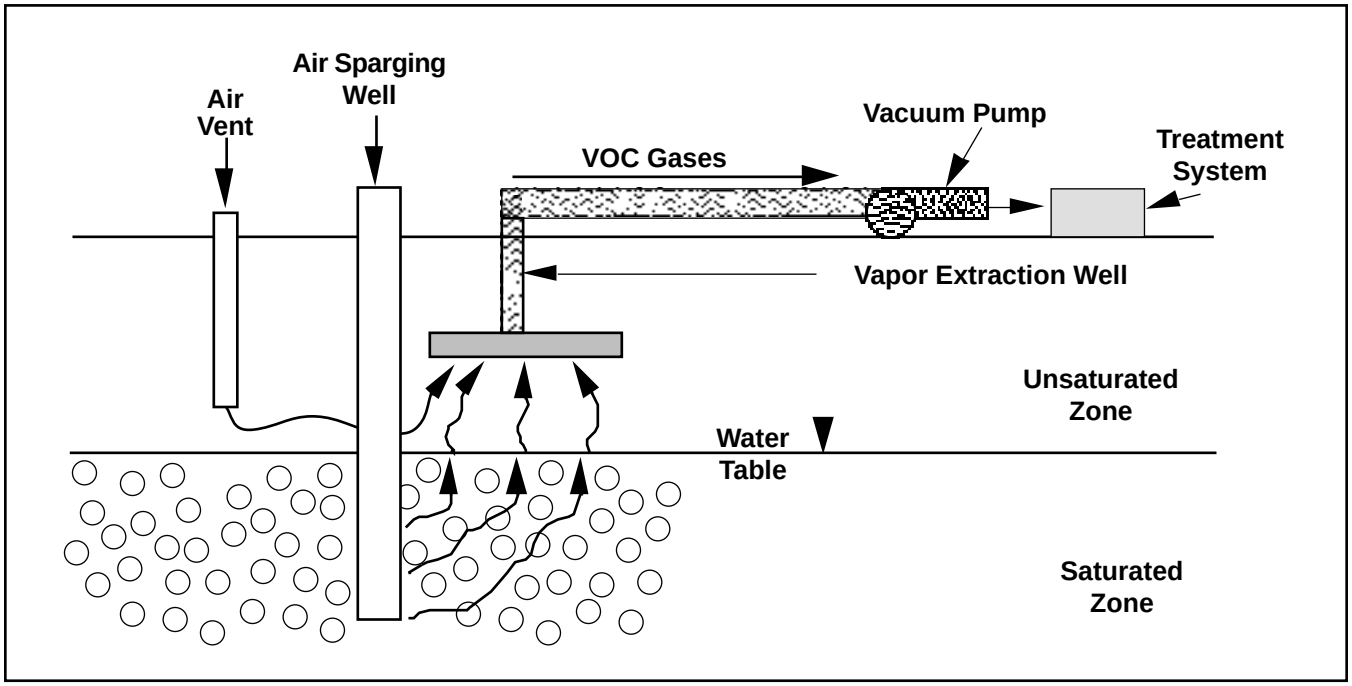
A Quick Look at Soil Vapor Extraction

- Pulls contaminants from soil in vapor form.
- Provides an oxygen source which may stimulate bioremediation of some contaminants.
- Most frequently used innovative treatment technology.

A Quick Look at Air Sparging

- Extends the effectiveness of soil vapor extraction to include contaminants that exist in ground water.
- Can accelerate cleanup at pump-and-treat sites.
- Provides an oxygen source which may stimulate bioremediation of some contaminants.

Figure 1
A Combined Soil Vapor Extraction/Air Sparging System



As with SVE, an added benefit of air sparging is that it provides an oxygen source that helps stimulate the *bioremediation* of some contaminants. Bioremediation is an innovative treatment technology that uses microorganisms, such as bacteria, that live in the soil or groundwater to break down contaminants into harmless substances. (Bioremediation is explained in detail in another Citizen's Guide. See the "For More Information" box on page 4.) Air sparging also can be a quick and effective treatment for VOCs in groundwater.

How does an SVE system work?

The first step to constructing an SVE system is to install vapor extraction wells and injection wells (or air vents) in the contaminated area. Air injection wells use air compressors to force air into the ground. Air vents serve the same function as air injection wells, but are passive—instead of pumping air they just provide a passage for air to be drawn into the ground. When incoming air passes through the soil on its way to the extraction wells, contaminants evaporate out of the spaces between the soil particles and are pulled by the air to the wells and removed.

Vapor extraction wells can be placed either vertically or horizontally. Typically, they are placed vertically and are designed to penetrate the lower portion of the unsaturated zone.

Vapors extracted by the SVE process are typically treated using carbon adsorption, incineration, catalytic oxidation, or condensation. Other methods, such as biological treatment and ultraviolet oxidation, also have been used with SVE systems. The type of treatment chosen depends on which contaminants are present and their concentrations.

Carbon adsorption is the most commonly used treatment for contaminated vapors and is adaptable to a wide range of volatile organic compounds.

When properly designed and operated, SVE is a safe, low maintenance process. Explosion-proof equipment is available to handle the potentially explosive mixtures of extracted gas that may be encountered on some landfill or gasoline spill sites.

SVE with thermal enhancement. SVE performance can be *enhanced* or improved by injecting heated air or steam into the contaminated soil through the injection wells. The heated air or steam helps to "loosen" some less volatile compounds from the soil. Researchers have done large-scale demonstrations of SVE with steam injection at several sites. In

addition to heated air or steam, another enhancement of SVE is the use of radio-frequency (RF) heating to better vaporize or volatilize compounds in clay and silt-type soils. Demonstrations of RF heating are underway.

Dual phase extraction. Dual phase extraction is a treatment system similar to SVE, but the extraction wells are sunk more deeply into the ground—below the water table into the saturated zone. Strong vacuum is applied through the extraction wells to simultaneously remove groundwater and vapors from the subsurface. Once above ground, the extracted vapors and groundwater are separated and treated. Dual phase extraction is more effective than SVE at sites with dense, clayey soil. When dual-phase extraction is combined with bioremediation, air sparging or bioventing, it can shorten cleanup times.

Why consider SVE or air sparging?

SVE is very effective at removing VOCs from the unsaturated zone. With the addition of an air sparging system, contaminants can be removed from the saturated zone as well. Neither technique requires excavation of the contaminated soil. (Excavation is undesirable because it is expensive, creates dust, and allows volatile contaminants to escape untreated into the atmosphere.) The extracted vapors usually require treatment, but costs for treating extracted vapors and liquids are low compared to the costs of technologies requiring excavation. The technologies are relatively simple to install, can be used effectively in combination with other treatment technologies, and are effective under a variety of site conditions.

Will SVE or air sparging work at every site?

SVE and air sparging may be good choices at sites contaminated with solvents and other volatile organic compounds (such as trichloroethane, trichloroethylene, benzene, toluene, ethylbenzene, and xylene) and fuels. Because properties of the soil have such an important effect on the movement of soil vapors, the performance and design of SVE and air sparging systems depend greatly on the properties of the soil. SVE is best used at sites with loose unsaturated soil, such as sand, gravel, and coarse silt or fractured bedrock. However, it has been applied to sites with denser soils, although treatment may take longer. Also, the higher the moisture content of the soil, the slower SVE works.

Where are SVE and air sparging being used?

SVE has been used at many Superfund and other hazardous waste sites. The Verona Well Field in Michigan is a Superfund site at which SVE was used to treat a one-half acre area to a depth of 20 feet contaminated with trichloroethene, tetrachloroethylene, and "BTEX," a mixture of benzene, toluene, ethylbenzene, and xylene. The SVE system removed and treated a total of 45,000 pounds of contaminants from the treatment area. EPA set target cleanup levels for 19 different contaminants at the site and the SVE system successfully met the goals for all the contaminants. Table 1 on page 4 lists other Superfund sites at which SVE, air sparging, and dual-phase extraction are planned or have been used.

What Is An Innovative Treatment Technology?

Treatment technologies are processes applied to hazardous waste or contaminated materials to permanently alter their condition through chemical, biological, or physical means. Treatment technologies are able to alter, by destroying or changing, contaminated materials so they are less hazardous or are no longer hazardous. This may be done by reducing the amount of contaminated material, by recovering or removing a component that gives the material its hazardous properties or by immobilizing the waste. *Innovative treatment technologies* are technologies that have been tested, selected or used for treatment of hazardous waste or contaminated materials but still lack well-documented cost and performance data under a variety of operating conditions.

Some innovative treatment technologies, such as SVE and thermal desorption, are so widely used that the term "innovative" may seem inappropriate. However, innovative variations on these technologies are still being developed and EPA still is not able to predict with certainty the time and cost required to clean up a site using them. For these reasons, EPA continues to track these technologies and collect data about them.

Table 1
Examples of Superfund Sites Using Soil Vapor Extraction (SVE), Air Sparging (AS), or Dual Phase Extraction (DPE)*

Name of Site	Technology	Status**	Contaminants
Fairchild Semiconductor (San Jose), CA	SVE	Completed	Volatile organic compounds (VOCs), benzene, toluene, ethylbenzene & xylene (BTEX)
Garden State Cleaners, NJ	SVE	Completed	VOCs
Defense General Supply Center, VA	SVE	Completed	VOCs
Hollingsworth Solderless, FL	SVE	Completed	VOCs
Rocky Mountain Arsenal, CO	SVE	Completed	VOCs
Lindsay Manufacturing, NE	SVE	Operational	VOCs
Applied Environmental Services, NY	SVE/AS	Operational	BTEX, VOCs, semi-volatile organic compounds (SVOCs), polyaromatic hydrocarbons (PAHs)
Wayne Reclamation and Recycling, IN	SVE/AS	Operational	VOCs, BTEX
Sand Creek Industrial, CO	SVE/DPE	Predesign	VOCs, PAHs, BTEX
Linemaster Switch Corporation, CT	SVE/DPE	In design	VOCs
Rochester Property, SC	AS	Operational	VOCs
Fairchild Air Force Base, WA	AS	Operational	VOCs, BTEX

For a listing of Superfund sites at which innovative treatment technologies have been used or selected for use, contact NCEPI at the address in the box below for a copy of the document entitled ***Innovative Treatment Technologies: Annual Status Report (7th Ed.)*****, EPA 542-R-95-008.** Additional information about the sites listed in the Annual Status Report is available in database format. The database can be downloaded free of charge from EPA's Cleanup Information bulletin board (CLU-IN). Call CLU-IN at 301-589-8366 (modem). CLU-IN's help line is 301-589-8368. The database also is available for purchase on diskettes. Contact NCEPI for details.

** Not all waste types and site conditions are comparable. Each site must be individually investigated and tested. Engineering and scientific judgment must be used to determine if a technology is appropriate for a site.*
***As of August 1995*

For More Information

The publications listed below can be ordered free of charge by calling NCEPI at 513-489-8190 or faxing your request to 513-489-8695. If NCEPI is out of stock of a document, you may be directed to other sources. Write to NCEPI at:

National Center for Environmental Publications and Information (NCEPI)
P.O. Box 42419
Cincinnati, OH 45242

- *Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation: A Bibliography of EPA Resources,* January 1995, EPA 542-B-95-001. **A bibliography of EPA publications about innovative treatment technologies.**
- *Soil Vapor Extraction Treatment Technology Resource Guide,* September 1994, EPA 542-B-94-007. **A bibliography of publications and other sources of information about SVE, air sparging and other innovative treatment technologies.**
- *In Situ Remediation Technology Status Report: Thermal Enhancements,* April 1995, EPA 542-K-94-009.
- *Technology Assessment of Soil Vapor Extraction and Air Sparging,* September 1992, EPA 600-R-92-173.
- *Superfund Innovative Technology Evaluation Program: Technology Profiles (7th Ed.),* EPA 540-R-94-526.
- *A Citizen's Guide to Bioremediation,* EPA 542-F-96-007.
- WASTECH® Monograph on Vacuum Vapor Extraction, *ISBN #1-883767-08-3. Available for $49.95 from the American Academy of Environmental Engineers, 130 Holiday Court, Annapolis, MD 21401. Telephone 410-266-3311.*